Oak Ridge National Laboratory

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DURING THE TWO YEARS that the development of nuclear energy in this country has been the responsibility of the U. S. Atomic Energy Commission, the large national laboratory has emerged as a new entity, a new experiment in the conduct of organized research. Each of the laboratories—Argonne, Oak Ridge, Brookhaven—bears an individual stamp imprinted by its history and its geography. This individuality manifests itself in differences in atmosphere, in program, and in aims. Thus, in order to understand the Oak Ridge National Laboratory it is necessary first to trace its history.

The laboratory was organized under the name Clinton Laboratories (after the town of Clinton, Tennessee, about eight miles from Oak Ridge), in the fall of 1943. At that time it was a branch of the Metallurgical Project—the University of Chicago Metallurgical Laboratory and the Clinton Laboratories comprised the major units of the Project, under the overall direction of Arthur H. Compton. The laboratory itself was directed by M. D. Whitaker, now president of Lehigh University.

The main job of the laboratory was to produce and extract plutonium on a gram scale in order to test the feasibility of the whole Hanford project. For this purpose an air-cooled graphite reactor was constructed. This reactor, the first with provision for large scale heat removal, began operation on November 4, 1943, and has operated satisfactorily as a research instrument and an isotope producer ever since. In addition, a chemical pilot plant for plutonium extraction was built; this is a relatively small version of the huge concrete structures at Hanford, where plutonium is extracted on a large scale by methods first proved at Clinton Laboratories.

Since the laboratories were in effect a pilot plant—at least on the chemical side—for the DuPont-operated Hanford Engineer Works, it was natural that the DuPont Company played an important role in the early history of Clinton Laboratories. The University of Chicago operated the institution; however, the scientists and engineers at the DuPont Company and at the University of Chicago collaborated in designing the reactor and the chemical facilities, and DuPont was the construction contractor for the whole installation. In addition, the laboratories were used as a training ground for the workers at DuPont who were ultimately destined to operate the Hanford establishment. Many of the laboratory's operating staff were actually DuPont employees on loan to the University of Chicago. Thus industrial and academic influences have both been strongly felt at the laboratory from its earliest days. An atmosphere which is a blend of these two has naturally developed there.

The original purpose of Clinton Laboratories dictated the composition of its staff. Chemistry and chemical engineering (the chemical engineering carried out in the "technical" division, so called because the name is in common use by the DuPont Company) made up more than ninety percent of the scientific effort. This emphasis on chemistry and chemical engineering at Oak Ridge has in some measure persisted ever since. In addition, there was a small physics staff that directed the construction of the reactor and performed experiments with it, a small biology and medical staff, and an operation staff of technicians who later took charge of the routine production of radioisotopes. The technical direction of the laboratory at this time (1943–46) was the responsibility of R. L. Doan, research director.

Oak Ridge functioned as an adjunct of the Chicago Metallurgical Laboratory all through the war. Relations with Chicago were extremely close—monthly information meetings were held there at which research results from the two groups were exchanged and discussed. There were many problems—usually chemical—which were attacked jointly.

The very close relation between Clinton and Chicago remained until the end of the war. In June 1945, when the laboratory population had grown to 1,088, 250 of them technical staff members, it was arranged by the Manhattan Engineer District to transfer the laboratory operating contract to the Monsanto Chemical Company of St. Louis. The laboratory therefore withdrew from the University of Chicago Project and embarked on an independent course, with an overall program much broader than the originally conceived program of chemistry and chemical engineering. A number of scientists from Chicago who had been interested in the long range possibilities of atomic energy joined the laboratory, and its program veered toward the development of new reactor types. Physics and mechanical engineering were strengthened, since these disciplines are important for reactor development. In addition, there was a general broadening of the laboratory's work in pure science.

The large scale production of radioisotopes for scientific and therapeutic purposes was established as an important function of the Clinton Laboratories in 1945. It has continued ever since to be one of the most significant activities of the laboratory—and in fact, one of the most significant activities of the whole Atomic Energy Commission.

In May, 1946, Dr. Whitaker left the laboratory to become president of Lehigh University, and Dr. Doan returned to the Phillips Petroleum Company, from which he had been on leave. E. P. Wigner, on leave from Princeton University for a year, was named director of research and development, and J. H. Lum of the Monsanto Company became executive director.

The year during which Professor Wigner directed the laboratory was one of intense activity and expansion. A metallurgy division was established, and the biology division increased greatly in size. Under the direction of A. Hollaender, its approach to the problem of the biological effects of radiation became microbiological and biochemical rather than mammalian. The physics, chemistry, technical, and health physics divisions also increased in size and scope.

The laboratory program centered even more closely than before around the science and technology of nuclear reactors, although this preoccupation with reactor development was not so much the result of Commission directive as it was the outgrowth of the natural interests of the staff, particularly Dr. Wigner.

One of the most interesting activities at the laboratory during this period was the Clinton Laboratories Training School, directed by F. Seitz. Professor Wigner and his group at the Chicago Metallurgical Laboratory had done a great deal of long range thinking on the possibilities of nuclear energy, and on the codification of nuclear technology into a discipline which had its own tradition and could be conveyed to newcomers in the field. Because of security restrictions it seemed impractical to carry out the necessary training in nuclear technology within the usual educational agencies. Professor Wigner therefore conceived the notion of establishing a nuclear technology training school within Clinton Laboratories. To this school were invited about 40 scientists and engineers, both industrial and academic, interested in entering the new field. The "students" took part in the regular laboratory activities besides attending classes given by staff members, and after the year's stay they were expected to carry their training back to their home institutions.

Although the training school operated for only a year its alumni include several of the best known figures in the American atomic energy effort. There were administrative difficulties of the sort that beset most enterprises at the outset, but the training school was a success as measured by the influence its students have had on the national nuclear energy development.

Professor Wigner's leave from Princeton ended in August, 1947. About the same time, the Monsanto Chemical Company decided, in agreement with the Atomic Energy Commission, not to renew its contract for operation of the laboratory. There followed a period of administrative uncertainty, during part of which the University of Chicago was the presumptive contractor. This period ended March 1, 1948, when the Carbide and Carbon Chemicals Corporation took over operation of the laboratory, now called Oak Ridge National Laboratory, on a four-year contract. The Carbide Corporation had already been operating the other two Oak Ridge installations—the K-25 gaseous diffusion plant and the Y-12 electromagnetic plant—and the extraordinarily well-equipped process and development laboratories connected with them.

Two events of extreme importance to the laboratory occurred during 1946–47. First, the Oak Ridge Institute of Nuclear Studies was organized. This agency, representing 19 southern universities,[1] seeks to establish cooperative arrangements between the Oak Ridge National Laboratory (as well as the other plant laboratories) and the member institutions in all scientific areas where such cooperation can be fruitful for the laboratory and for the member institutions. Thus, arrangements are made, via the ORINS, for students from outside universities to do Ph.D. thesis work at Oak Ridge. Again, faculty members of the ORINS universities are given the opportunity to work in Oak Ridge National Laboratory or in the plant development laboratories, to learn new techniques and to meet distinguished men in the field who often visit the laboratories, and to use this knowledge in their own research and teaching activities. In this respect the Oak Ridge Institute of Nuclear Studies operates in much the same way as do the Associated Universities at Brookhaven, or the Board of Governors at Argonne. It is to be hoped that the Oak Ridge National Laboratory will play a profoundly important part in the scientific and cultural development of the Southland. The degree to which this promise is fulfilled will depend, of course, on the imagination brought to bear on developing fruitful means of contact between the laboratory and the southern region.

[1] Alabama Polytechnic Institute, University of Arkansas, University of Alabama, Duke University, Emory University, University of Florida, Georgia School of Technology, University of Georgia, University of Kentucky, Louisiana State University, University of Louisville, University of North Carolina, University of Mississippi, University of Tennessee, Tulane University, University of Texas, University of Virginia, Vanderbilt University, Catholic University of America.

The second event of great importance was the decision, on December 27, 1947, to concentrate reactor technology at the Argonne National Laboratory and to concentrate at Oak Ridge chemical technology, isotope production, and basic research in chemistry, physics, biology, and metallurgy, the basic research to be carried out in such a way as to stimulate cooperation with the southern institutions and the ORINS. In a certain sense this decision represented a partial return to the original concept of the old Clinton Laboratories, the chemical engineering installation of the Plutonium Project. However, more and more of the laboratory's effort had been directed toward reactor technology and basic research since the early days. The decision to merge the ORNL reactor effort at Argonne naturally caused considerable uncertainty among the scientists at Oak Ridge, the degree of dislocation varying from division to division, depending on how the new directive affected work done there.

It is fair to state that the laboratory has readjusted to its new status remarkably well, and has even acquired greater stability and permanence, because:

(1) The question of contractor has been settled on a long term basis; (2) The relative positions of basic research in the sciences and applied chemical technology have been established—it has become clear that it is perfectly possible for the two to flourish side by side, and in fact, to be fertilized by each other in this juxtaposition; (3) Personnel relations at the Carbide and Carbon Chemicals Corporation are handled well, in a manner consistent with the fact that the scientific staff has an esprit de corps and a loyalty to Oak Ridge; (4) Finally, the role of the Southern universities in the laboratory has been defined, and the hope that Oak Ridge will become the center of basic research in the South materializes with each additional Ph.D. student, with each visiting faculty member, and with each lecture by an Oak Ridge scientist at a Southern institution.

At present the laboratory population is about 2,000, including about 600 technical staff members. The laboratory is divided into six scientific divisions: biology, chemistry, health physics, metallurgy, physics, and technical. In addition, there is an operating department, responsible for radioisotope production and pile operation, and several service departments.

About half of the laboratory's work is classified. The other half includes basic studies in many fields, some of which have already become almost classical. Among these studies are:

Neutron diffraction. This technique, for which the chain reactor is ideally suited, has become an extraordinarily powerful tool for the investigation of the structure of hydrogen-containing crystals. Since chain reactors are so expensive that in all probability only large organizations like national laboratories will ever be able to afford them, the use of neutron diffraction for the systematic study of crystals and molecular structure is apt to remain a most important basic scientific function of the national laboratories.

Ion exchange methods in inorganic chemistry. The systematic separation and purification of chemical compounds by selective adsorption on organic zeolites have been developed at ORNL as a tool in many chemical investigations. For example, the preparation of exceedingly pure (99.9% or better) rare earths was first performed at ORNL, and has since become a fairly routine procedure.

Isolation and chemical properties of elements 61 and 43. Element 61, prometheum, and element 43, technetium, were first isolated in milligram amounts at ORNL from the fission product wastes, and many of their chemical properties have been determined. The work on these elements typifies the sort of large scale "hot" operations which the extensive radiochemical facilities at ORNL make particularly feasible.

The facilities of the Oak Ridge National Laboratory bear evidence of the diversity which is the mark of a war-born activity. The biology division is housed in buildings which were intended for use in the electromagnetic isotope separation process, but which have been converted into one of the best-equipped biological laboratories in the world. The metallurgy laboratory is equipped with one of the largest exclusively experimental extrusion presses in the country; the physics division has at its disposal a helium liquefier and, jointly with the chemistry division, a Van de Graaf machine in addition to the chain reactor; the chemistry division possesses superb, high level, large scale hot laboratories, in addition to such relatively standard apparatus as an electron microscope and an X-ray and optical diffraction laboratory. This is only part of the equipment for which many millions of dollars have been spent at Oak Ridge National Laboratory since its inception.

In addition to the equipment at ORNL proper, there are available in the neighboring plant developmental laboratories excellent facilities for work in optical and mass spectroscopy, as well as huge vertical magnets suitable for cosmic ray investigations. Relations between ORNL and the two plant laboratories have been very close—to the mutual benefit of all three organizations—ever since the laboratory and the plants have been under one contracting agency.

Oak Ridge National Laboratory represents a unique experiment in scientific and governmental administration. It is a national institution operated by a private corporation for the purpose of furthering nuclear chemical technology on the one hand, and basic research, in conjunction with the Southern universities, on the other. It is thus a microcosm in which are projected many elements of our modern American—and Southern—society.

Can such an experiment be made to work? It is important to remember that the national laboratory for nuclear research is a new species—that there are no blueprints for the successful national laboratory—and that there are probably several administrative setups that will prove to be workable. It has been stated that industry is not suited to manage a national laboratory dedicated in good measure to basic research—yet the experience of ORNL during the last year under Carbide management has demonstrated that first-rate basic research can be done in an industrial framework. One important reason is the fact that the subtle relations between staff and contractor have been so handled as to take into account the basic loyalties of the staff, which go primarily to the national laboratory rather than to the contracting agency.

Again it has been suggested that the successful national laboratory should be located close to a large city. Oak Ridge is rather isolated. But life in Oak Ridge and the other atomic cities has many attractive features. There exist cameraderie and opportunities to take active part in community and cultural activities which are quite beyond the prospect of the average city dweller. In large measure these features of life in Oak Ridge compensate for the cultural advantages of the large city—which so often are available but are left unused.

But it may be that the laboratory draws its essential strength from its position as the largest scientific institution in the South. It is commonplace to observe that the Southland is undergoing a modern industrial revolution—that living standards are increasing, and that, as a concomitant, a cultural rebirth is in the making. But the South has a long way to go, especially in the sciences. In making its influence felt throughout the scientific departments of the Southern universities, Oak Ridge National Laboratory, through the agency of the Oak Ridge Institute of Nuclear Studies, has a worthy educational mission to perform. Should it fulfill this mission then this fulfillment—this curious by-product of the atomic bomb—will almost surely rank in importance with any future technical advances which Oak Ridge National Laboratory—or any laboratory—can hope to achieve.

On the Calculation of Planet Temperatures From the Composition of Meteoritic Matter

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IN A RECENT PAPER, BROWN AND PATTERSON (*2*) STATE "the conclusion appears irrefutable that meteorites at one time were an integral part of a planet" similar in characteristics to the earth. The evidence for this conclusion which they emphasize especially consists of certain thermodynamic computations made on the basis of data which they have compiled. Careful analysis indicates, however, that even if we grant the assumptions involved in making these computations and even if we use the data assembled by Brown and Patterson, we should arrive at conclusions which are at variance with those proposed by these authors.

Brown and Patterson's thermodynamic calculations depend fundamentally on the assumption "that the observed distributions of elements [within meteorites] represent equilibrium distributions . . . [which] must have been established at temperatures of the order of 3,000° C and pressures of the order of 10^5–10^6 atms." The pressures specified depend, in turn, on the value assumed for the equilibrium temperature. It seems pertinent, therefore, to examine carefully the basis of the particular choice of temperature, and the degree of reliability of the value proposed.

The choice of 3,000° C as the equilibrium temperature is based on the correlations of data on equilibrium distributions between silicate and metal phases with the heats of formation of the oxides, in terms of the following *approximate* thermodynamic expression:

$$-RT \ln K \simeq \Delta H. \qquad (1)$$

The reliability of the calculated temperature depends, therefore, on the closeness of ΔH's for the formation